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A good grounding in mathematics is a prerequisite for anyone wanting to become an engineer. However, studies have shown that by high school, most girls avoid math. Many factors contribute to this mathematical discomfort in girls. Female elementary teachers, cultural and social emphases, even toys and books all combine to tell girls they cannot be good at math. One way to dispel this misconception and increase the pool of young women able to consider engineering is to relate mathematics to real life and to present positive roll models in elementary school. A family-centered mathematics carnival can be run as an annual joint program with the local SWE section, other local science and mathematics organizations, the school and the parent group. Activities are available for age groups from kindergarten through eighth grade. Interesting and enjoyable mathematics games help both parents and children see that math is much more than dull school exercises. With each yearly carnival series, the kids discover that math is fun and see that women can not only do well in mathematics, but also use it in real life as engineers. This paper will provide a methodology and tips for organizing such Math Carnivals.

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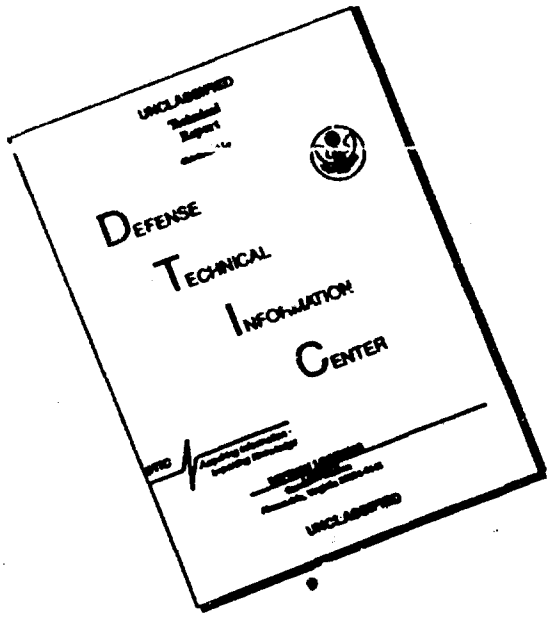

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MATH CARNIVAL NIGHTS
(Planting the Seeds for Engineers in Elementary School)

Therese Dougherty

Abstract

A good grounding in mathematics is a prerequisite for anyone wanting to become an engineer. However, studies have shown that by high school, most girls avoid math. Many factors contribute to this mathematical discomfort in girls. Female elementary teachers, cultural and social emphases, even toys and books all combine to tell girls they cannot be good at math. One way to dispel this misconception and increase the pool of young women able to consider engineering is to relate mathematics to real life and to present positive roll models in elementary school. A family-centered mathematics carnival can be run as an annual joint program with the local SWE section, other local science and mathematics organizations, the school and the parent group. Activities are available for age groups from kindergarten through eighth grade. Interesting and enjoyable mathematics games help both parents and children see that math is much more than dull school exercises. With each yearly carnival series, the kids discover that math is fun and see that women can not only do well in mathematics, but also use it in real life as engineers. This paper will provide a methodology and tips for organizing such Math Carnivals.

The Problem

Mathematics is called the language of science. And just as some opt not to learn Spanish or German, many see no need to master the language of mathematics. Unfortunately, there is a major difference between mathematics and other foreign languages. While one can manage to live in California without German, for example, the same cannot be said for mathematics.

"When are we ever going to have to use this?" is a common plaint of most math students. Hal Sanders, a Santa Barbara Junior High teacher attempted to provide an answer by a survey he performed in the late 1970's and documented in an article for The Mathematics Teacher in January 1980. He interviewed a representative from each of 100 different occupations to determine what math skills each used on the job. The group covered a wide cross section of occupations and was not limited to those jobs we normally associate as needing math skills. Those interviewed included an accountant, a graphic artist, an auto mechanic, a carpenter, engineers from several disciplines, a newspaper reporter, a police officer, an optician, a travel agent, an urban planner, a waiter and a wastewater treatment operator.

One hundred percent of those surveyed used decimals. The requirements to use a calculator (98%) and the ability to calculate percent (97%) were almost as pervasive. Over 80% of those interviewed use math skills in estimation, fractions, and averaging. More than 60% required math skills in ratio and proportion, statistical graphs, formulas and basic geometric concepts. Hal Sanders warned that his was a very small cross section and these values would vary somewhat with a larger sample, but the need for math skills is clearly demonstrated.[1]

This importance is borne out by a listing of high school math courses required for various jobs provided by the Mathematical Association of America.[2] Obviously, would-be engineers and physicists need as much math as possible, but the list isn't limited to these math intensive jobs. Students planning to major in business administration, economics, psychology, and architecture need three years of math in high school. For a liberal arts major in art, history, law or sociology, the student needs to have completed two years of high school math. In order to work effectively as airline pilot, veterinarian, or astronomer the student must have four years of high school math. Even students planning to enter "non-math" jobs like policeman, fire fighter, carpenter or bank teller require a minimum of two years of high school math to work effectively.

That's a fairly impressive cross section. Unfortunately, many people do not see this need for math. Even schools sometimes give the impression that math is not as essential as reading. A contributor to this is the perception that "some people just can't do math." (The people in question are usually girls and women. This perception, in turn, leads to lowered expectations. You will not hear a teacher or anyone else excuse a child from the requirement to learn to read because "the poor dear just doesn't have a head for reading." It happens, although perhaps not in those exact words, with respect to math.

Many studies[3] have tried to identify the reason for this female "math-phobia." Their findings indicate that girls and boys start off equal in math and science performance and interest. However, once girls reach secondary school where math and science become optional courses, this parity evaporates. Past junior high, girls' enrollment, achievement, and interest in science and math follows a continuing downhill spiral.[4] Although girls may outnumber boys in eighth grade advanced math courses, half as many girls as boys are enrolled in calculus.[5]

Even as recently as 1985, the math scores for women taking the Scholastic Aptitude Test (SAT) show girls remain behind boys in math. Although the girls' average scores had gained three points over the previous year, the average was still 45 points lower than that of the boys. The difference is even noticeable at the high range. Five percent of the male test takers scored above 700, while only one percent of the girls scored at that level. According to the Educational Testing Service, which designs the SAT, the difference is due to boys taking more math in all of high school and making a commitment to careers which require more math. The good news is that after reviewing ten years of studies comparing the performance of girls and boys in grades four to eight, the Educational Testing Service found no sex-linked differences in math capability.[6]

Cultural and social factors contribute to the lowered expectations and lesser math skills for girls. It wasn't very long ago that it was considered a waste to educate a woman. Unfortunately, these beliefs have not completely disappeared, even though they are not as widespread or acceptable as they once were. Society still is ambivalent about careers for women as is shown by handling of the child care issue, among others.

Another factor is the lack of math skills in many elementary teachers, who are predominantly women. This can be a double whammy. First, a person who is not comfortable with math has a hard time teaching it, much less making it enjoyable. And secondly, the female teacher is a role model for the girls. So, as the girl senses the teacher's discomfort with math, she learns to question her enjoyment. Many girls have no counter-balance provided by female relatives or friends who are successful in math.

Another, slowly changing, aspect of the cultural and social factors is the effect of children's books, games, and toys. For books, the difference is again a matter of expectations. Too many books for girls still reinforce the old stereotypes. These may be as blatant as omitting women's achievements, or always showing women inept as problem solvers. Others are more subtle; her brother invents things; she just uses them. Or, the author may use the masculine as the universal pronoun. Happily, books with a more balanced approach are slowly becoming available.

Boys' games such as baseball and football involve much use of mathematics. These range from simple arithmetic (how many yards for the next first down) to statistics (batting average, ERA, etc. in baseball). These games also emphasize estimating speed and trajectory. Little girls games such as jump rope and jacks often require little more than counting. Girls who play "boys" games have a definite math advantage over their more sedate sisters.

Toys are the most pervasive and unrecognized dividers. Little girls play with dolls, stuffed animals, and other related toys. Boys play with blocks, both the standard wooden ones as well as building blocks such as Legos(tm) and Lincoln Logs(tm). Later they play billiards, computer games and pinball. These not only increase spatial awareness, but provide hands on experience in geometry and trigonometry.

The school problem is compounded by the fact that classes often are taught with a "male bias." It's not just that boys are called on more often and commended for their thinking skills rather than for being quiet as little girls are. Math courses are taught the way men and boys think (which is logical, since that is the way most teachers were taught). The learning modes which are most helpful to girls are seldom included in standard textbooks. The fact that girls even have a problem with mathematics is barely recognized in method texts for mathematics. (On the other hand, every text for reading methods notes that boys have problems in reading. Each also includes possible techniques to augment the curriculum in this area.) Thus, the math teacher must first become aware of the problem, then has to search out ways to help girls with math, and finally must work any compensations into the classroom with little help from curriculum developers or the school administration.

The studies cited above identified that the mathematical capabilities and interests girls evidence in elementary school are being suppressed. Educational researchers and bureaucrats tend to study such problems to death. The practical thing is to determine what we can do now to help the young women in elementary school.

Strategies

The following are a few of the ways we can help girls (and boys, too) become more comfortable with math. The three strands from the EQUALS program[7] provide a good starting point. First we develop awareness of the importance of mathematics and the options it opens. The second strand builds confidence by providing strategies and experiences of success in mathematics. The third strand, encouragement is an outgrowth of the other two and motivates students to continue in math and expand their career options.

Awareness includes not only experiments like the one described above relating occupations to math needs, but also those which show just how much math we take for granted in our daily lives. Estimating, making change, altering the number of servings in a recipe, even modifying the hem in a dress, or figuring out gas mileage are all mathematical experiences. Others are figuring how many gallons you need to put two coats of paint on a wall, or how many plants will be needed to cover a garden area, given the plants will grow to a specific size. Even games such as Battleship and tangrams are math oriented. Sometimes awareness is just "turning on the light" to show people how much they already know.

Developing this mathematical awareness can be almost as important for girls as learning the math concepts. Awareness also includes learning about nontraditional or unfamiliar occupations. Considering certain jobs as "men's work" and others as "women's work" limits opportunities and career options. Women engineers and other women in technical fields can provide especially valuable role models in this respect. By showing that women can succeed in a "man's career," women engineers free both girls and boys to consider nontraditional options.

Confidence is built on success by starting with manageable problems which gradually become more challenging. Another aspect of confidence building is to emphasize "female" modes of learning, such as cooperative learning and increased use of manipulatives.

By establishing both single sex and mixed sex cooperative work groups, we provide a less threatening environment. Single sex groups provide a chance for girls to solve math problems without the intimidation they may feel in a mixed sex group. The transition from a single sex group to a mixed sex group allows a female "math whiz" to freely express herself in the girl's group and yet be just a team member when the boys are around. The goal is to provide freedom from social pressures. As the girls become more comfortable with their capabilities, the pressure lessens.

Much of the literature emphasizes the competitive nature of men, whether individually or as members of a team. Women, on the other hand, tend to emphasize cooperative effort. They are generally not as eager for, nor as comfortable with, competition as men are. One way to ease

young women into competition is by having competition between groups. This blends the best of both worlds. Girls can move from the comfortable cooperative environment to what is often a less comfortable area of competition.

However much we may laud cooperative efforts, independent work is also an important aspect of mathematics. There must be balance between the flash card approach for drilling and reviewing math facts, and a supportive, less pressured atmosphere where speed is not the primary driver. Speed and results are necessary in verifying math facts and in testing situations. Faster does not always mean better, however. Some problems need to be examined and then let sit to be gone over later with a new perspective. This "wait and percolate" method often doesn't fit within the classroom situation.

As discussed earlier, girls especially need experience in use of manipulatives. ."Everyone knows girls are more verbal than boys." Whether its true or not, the result is that girls are often steered more toward verbal, conceptual activities. Developmental theorists maintain that we cannot manipulate the abstract until we have learned to manipulate the concrete. Teachers in primary grades often use manipulatives, but hands on activities usually disappear from the classroom shortly thereafter. However, manipulatives are powerful tools which can provide valuable mathematical insights all the way through high school. The great thing about manipulatives is that they don't have to be blocks or paper. A really fun exercise is to determine the proportion of different colors of M&Ms(tm) in a bag. Best of all, guess what happens to the candy when you are done?

Family Math Carnival

The above strategies are still pretty theoretical. So, let's discuss the Math Carnival. The word "Carnival" was chosen to suggest fun and excitement with games of chance and skill. Math, fun math, is the theme for our carnival. The object is for parents and children to explore problem solving strategies together using "hands on" materials in a relaxed atmosphere.

The phrase, "parents and children," is very important. The parents of the young people who attend will be continuing influences on their children. For this reason, the best grouping is where parent and child play and learn together. In the event this can't happen, the following should be made clear from the beginning: parents and other interested adults can come with or without a kid, but no child can come without an adult. This is necessary to keep the carnival from becoming just a tutorial for the kids. We need to get the parents involved so they can continue to reinforce the ideas we will be presenting, and perhaps increase their awareness, too.

In order to build the confidence discussed earlier, we need a continuing experience. The optimum is to have sessions about 90 minutes long, once a week over four to six weeks. Obviously, the length will depend on how much support you get. This is not something one person can do alone. Even if you can't do a full series the first time, by careful choice of activities, you can provide a foundation to use in future years.

Key to success is the carnival team, which should be as large as you can comfortably use. A primary requirement is that team members enjoy math and feel comfortable with it. Team members should be familiar with the activities being presented, so they can model and explain the activities. Then the leaders need to keep hands off so the participants do everything themselves. It is important that participants have the freedom to do it "the wrong way." Errors and "dead ends" can teach a lot. In discussing and presenting activities, leaders should make the distinction between solutions and answers. The solution, how you get to the answer, is the important thing.

This Math Carnival description is aimed towards the intermediate grades through junior high. Girls in this group know most of the math basics, but are at risk of buying into the myth of female math inferiority. They are still at a point in their lives and schooling that a program such as this can make a significant impact. Carnival activities can be slanted toward a younger group also. However, differences in knowledge and learning capabilities suggest greater success using separate programs for primary and older groups.

Scheduling the carnival involves selecting both the time of year and the time of day. For some reason, attendance seems to be better in the fall or winter than in the spring. You will need to avoid school vacations, holidays and busy times (such as the last half of December). Also, early evening seems to work out best for most folks, although Saturday mornings are sometimes a good option. You may want to check with targeted students by sending out a recruitment notice or flyer, including a portion for the family to return indicating their preferred time.

A school classroom or library, a church, or community center are just a few of the possibilities for the location of the Carnival. Another possibility is to coordinate with a local company and use their cafeteria or meeting rooms. Any room can be used as long as it is large enough to allow for several stations for small group work and also provide an area for large group discussions. The furniture must be moveable. You also should ensure availability of ample parking in a safe area for night classes. Since many families have younger children, it is a definite plus if you can have a separate room for the very young children and provide a babysitter. The goal here is to find a place with either no charge for use of the facilities, or as small a fee as possible.

In some ways, the Carnival is like a nuclear reaction. You need enough people to provide a critical mass for the exchange of ideas. However, too many participants can cause an explosion, especially if there isn't enough room or materials. That ruins the experience for everyone. Here's where the flyers mentioned earlier can be of real help. You can use the response as an indicator of the possible turn out. If your space is limited, you may require reservations and set up a waiting list. An interesting fact is that requesting even a $5 registration fee for the series improves attendance. The families usually get back almost the full registration amount in handouts and manipulatives to use at home. It seems people make a greater commitment to attend if they pay something. (It goes back to "how good can it be if its free?") To ensure that no one who wants to attend is kept away by the cost, the fee must be kept minimal and/or scholarships given.

This gets us into the question of money. Some of the nonrecurring costs are covered below under the section on Sources. There will be recurring costs for such things as handouts and materials, rent, refreshments, and possibly postage for publicity. The cost for the handouts and materials is small; about $5 per family is a reasonable estimate for a 6 week session. Rent is no problem if you can get a place for free. Refreshments are nice to have, especially a pot of coffee, some juice, and maybe cookies. You can either try to get these donated by local businesses, or perhaps team members or parents would be willing to take turns.

Don't be afraid to ask for donations of all kinds. Businesses, philanthropic organizations, other professional societies, even the local grocery store and gas station -- most will find the idea exciting and will do what they can to encourage it. The schools in many places are having problems with funding, but they can still help by lending rulers and scissors, etc. in addition to possibly providing a meeting room.

Putting the Math Carnival together

Preliminary So now you have this mass of humanity heading for your meeting room, what do you do? Plan to be there almost an hour early the first day just to be sure you have everything ready. Hand out name tags as the participants walk in. Even people who see each other all the time in the community don't know each other's names. It's a great ice breaker.

You will want to keep a list of those attending. Don't use the standard boring sheet of lined paper; have everyone sign in on a large Venn Diagram. This is a great place to exercise your creativity. A simple Venn Diagram would use interlocked circles stating "I am wearing blue" and "I am wearing a watch." Perhaps for the first day you could learn about the participants by a linked series of ovals titled "I am a female," "I have used a computer," and "I enjoy math." Or choose your own. You can use a differently shaped diagram and different statements for each session.

Openers People seldom come all at the same time, so you will want to plan a number of simple start-up exercises that can be done with smaller groups. One idea is to hand two people a calculator and have them play a calculator-based version of the strategy game Nim. The object is to be the first (or last) to exactly reach a number by adding or subtracting specific digits. Start with 0 and add 1 or 2 on each turn. The winner is the first to reach 7 without going over. Next you could start with 11 and subtract 1 or 2 on each turn. The winner is the one who reaches 0. The game becomes more complex when you start at 0 and add 1, 2, 3, or 4 with the winner exactly reaching 21. How different is the strategy if you start with 2001 and subtract 1-99 each turn with the goal of being first to reach 0? Obviously, these games must each be played several times to figure out the strategy that works.

This is also a good time to use the calculator for experiments on the order of operations. The group can see how many different answers they can generate using the same set of numbers and operations in the same order by changing the number and placement of parentheses. Keeping the same set of numbers but changing the order and operations, what is the largest number that can be made? the smallest?

Another game takes a different look at flash cards. One hundred cards numbered from one to 100 are shuffled. Each member of the group takes turn in picking a card and showing it to the others. Each of them must then find the factors of the number shown. You can give extra points for being the first to recognize a prime number.

Tangrams are another fun start-up activity. Each member of the group can make a set of tangrams to experiment with and keep. (Tangram patterns can be run off on heavy paper or tag board so they last longer.) A simple start is to see how many pieces are needed to make different geometric shapes. The next step is to make more complex shapes; check for books of tangram ideas or have the group make their own. One company[8] took the tangram idea in a different direction. They cut a ceramic egg-shaped oval into nine differently shaped pieces which can be used to made 30 different bird shapes. Once your Carnival has been in swing for a couple weeks, you may want to let participants try to make their own tangram type puzzles from simple geometric shapes.

Introduction After about 10-15 minutes, everyone should be well into the spirit of things. (And most of the stragglers should have wandered in.) Now is a good time to formally introduce the team to the participants, and to give them an overview of the evening. If it is the first night you will introduce the participants to the intent and goals of the Carnival series.

Discuss the opening activity. Let the participants share what they learned. You can add any details or insights they may have missed.

If there were home exercises from the previous week, you may want to discuss the results here. Activities that are too time intensive to do during the 90 minute session but which you feel are too good to miss make good candidates for home exercises. Just make sure you have explained them clearly before hand. Some home activities may be outgrowths of previous Carnival experiments. Others may be introductions for future experiments. If a home exercise was planned as lead-in for a new activity, you may want to hold the discussion in conjunction with the activity.

Activities As Confucius should have said if he didn't, "It is better to do a few things well than many badly." You will want to limit activities to no more than three or four per session. Allow enough time for each group to understand and explore each activity. An adequate allowance is usually 15-20 minutes per activity. Also allow an additional five or so minutes to summarize and discuss the object or intent of each activity. Note that this discussion is held AFTER the participants have completed the activity.

There are so many great activities available, the hard part will be to keep from trying to do too much. You can select a theme for the evening, for example spatial visualization, and have all

activities support the theme. Or you may want to stretch the themes along time, providing increasingly complex activities for succeeding sessions.

Another option is to provide a smorgasbord. You could have several stations or work centers scattered about the room with a team member assigned to each. Participants would then spend a set time at each chosen activity center. If you have more centers than time slots, this one can be harder to manage, since every one will not get to each center. As a result, it is more difficult to plan for materials and handouts. You also need a larger, more open room; with everyone working on something different, it gets really noisy.

Activities should be chosen from many different types including Word Problems/Logical Reasoning, Strategy Games, Spatial Activities, Patterns, Estimation and Measurement and Career Explorations. Also, you may want to ask the parents if there is something in the middle school/junior high curriculum that they never really understood, but wished they had. Those can be emphasized in future sessions. The Family Math book lists math topics taught at each grade.

Spatial Activities are usually real winners. It's great fun to hand a group of adults and children each a 3x5 index card and a pair of scissors and tell them that they have to cut the card in such a way that they can step through it. Cutting the card in half allows you to walk between the card, and doesn't satisfy the requirement. Have plenty of extra cards on hand. [There are at least two different solutions to this one.]

For cooperative exercises, the EQUALS program put together a very helpful book with experiments in many different areas[9]. Participants work in groups of four. Each activity consists of four to six cards, each containing a piece of the problem. The four primary clue cards provide all the information needed to solve the problem. The two remaining cards provide hints in case the group needs help.

Mirrors are also interesting tools. You can use them to study both symmetry and angles. Give each participant a mirror and a sheet with the alphabet in block letters (check with your local primary teacher to borrow some of these). Each participant or group can confirm which letters have which type of symmetry. Then they can take the mirrors and see what other shapes they can create from the alphabet letters using the mirrors. It's fun to take other line drawings and pictures and create new pictures from them using the mirror and symmetry. Taping together two mirrors and setting them at different angles to each other, it is possible to turn one star into as many as twelve. With the mirrors at 120° apart, three stars appear. As the angle between the mirrors decreases, the number of stars increases. Twelve stars are visible when the mirrors are 30° apart.

One of my all-time favorite math books for use with student groups is How Much Is a Million?[10] The examples are fanciful and really give a feel for those numbers so large they are mostly beyond our comprehension. But the best part of the book is the notes in the back. There, the author explains how he developed his comparisons. For example, given that you can count from one to 100 in less than a minute, it is not intuitively obvious that it would take 23 days to count to a million, or 95 years to count to one billion. But 200,000 **years** to count to a trillion seems way out of line. Once you work out the math, however, it is a reasonable estimate. One way to use this book in an activity is to have the participants estimate what a million of something is and then calculate how close the estimate is.

Career explorations can include presentations by people in specific careers. But that's just a start. Another activity uses questions and answers about working women to explore how far women have gotten in certain careers. SPACES[11] includes the following questions. What percent of employed doctors are women? [13.4%] What percent of employed electricians are men? [98.7%] What percent of employed architects are men? [94%] Women are 52% of the US population. What percent are they of the US engineering force? [4%] What percent of secretaries are women? [99.1%]

In addition to role models from the community, activities can present biographies of historical women who have contributed to mathematics. Luckily, more books are becoming

available to provide information about women in math and science. An interesting book you may find useful is Women, Numbers, and Dreams[12]. This book combines biographic information on each woman with several activities which pertain to her life's work.

Sponges For each session, you should plan a number of "mini activities" for those who finish the regular activities early and want to try something else. Teachers refer to these as "sponges," since they help suck up excess time and energy which would otherwise be lost. These can be less complex versions of some activities you don't have time to explore in depth, or some that give a quick zing of an idea. Some of the openers work well as sponges also.

One note I would make here. Don't just do something once and then leave it forever. Yes, it is boring to do the same exact thing over and over, but the books list many activities which build on one another. Also, it doesn't take a major change to create a new activity from an old one.

Evaluations Plan to have the participants give you some form of evaluation at the end of each session. This can help you find out about and change something that doesn't work. Also you may want to change the emphasis, such as responding to the parents' curriculum concerns described above.

A very important use of the evaluations is to tell you if your activities are at the proper level for your group. If they are too hard, you can't meet the goal of making math fun. Nor can you if the activities are too easy and boring. For the first time, plan a mix and go from there. Make sure though that you do provide some challenging activities. One complaint about some school Math Nights is that some of them do only the easy stuff.

Sources

Now you have the format for the Math Carnival, but where can you get challenging, fun activities without spending a mint? Nonrecurring costs need not be excessive. Most of the activities discussed in the paper were developed under programs[13] of the Lawrence Hall of Science at the University of California, a public science center, teacher training institution, and research unit in science education. Each of their programs is described in a book[14] full of activities available from the Lawrence Hall of Science. The books include activities to explore math skills, knowledge of career options, and awareness of how girls "do" mathematics. Perhaps the best part of the material from the Lawrence Hall of Science (and from the National Women's History Project also) is that they not only give permission, but encourage you to make copies to use in your workshops.

Before you buy the books, check with the mathematics resource teacher at your local school district. She (he?) may have some of these you can borrow, or suggest other nearby sources both for these books and others.

Another source for both activities and support is your local council of mathematics teachers. Here in San Diego, the group is the Greater San Diego Mathematics Council. They have a very informative and interesting conference each year, which is where I gathered much of my information.

Good luck and enjoy yourselves!

Notes:

1. An interesting exercise you may want to include as part of your math carnival would be to have the participants continue and expand on the survey performed by Mr. Sanders. It may be valuable to use this as a home exercise extending over a couple of class periods to let the students interview more people.

2. Booklets by the Mathematical Association of America: "The Math in High School You'll Need for College," 1978 and "You Will Need Math," 1980

3. Elizabeth Fennema, "Sex Differences in Mathematics learning, Why??" Elementary School Journal, 73 (1974), 183-90; Thomas L Hilton and Gosta W. Berglund, "Sex Differences in Mathematics Achievement: A Longitudinal Study," Journal of Educational Research, 67 (1974), 231-37; Eleanor E. Maccoby and Carol N Jacklin, The Psychology of Sex Differences (Stanford, CA: The Stanford University Press, 1974)

4. John Ernest, Mathematics and Sex (Santa Barbara, CA: University of California, 1976); Elizabeth Fennema and Julia Sherman, "Sex-related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors," American Educational Research Journal, 14 (1977), 51-57; National Science Foundation Directorate for Science Education, Science Education Databook (Washington, D.C; US GPO, 1980)

5. Data gathered in the 1978-1980 Math/Science Desegregation Project of the Novato (California) Unified School District.

6. Patricia McCormack (UPI), "Girls' math lack explained by lack of interest" San Diego Union, October 8, 1985.

7. The EQUALS program was developed by the Lawrence Hall of Science at the University of California, Berkeley. This is a program for teachers to focus on the math avoidance of young women. EQUALS works through the educational system to increase the participation and interest of young women in mathematics, thus increasing their occupational opportunities.

8. The David Corporation, P.O. Box 66, Lake Oswego, Oregon 97034.

9. Tim Erickson, Get It Together (Math Problems for Groups Grades 4-12) Berkeley CA: EQUALS, Lawrence Hall of Science, 1989.

10. David M. Schwartz, How Much is a Million? New York: Scholastic, Inc, 1985

11. Sherry Fraser, project director SPACES - Solving Problems of Access to Careers in Engineering and Science Palo Alto, CA: Dale Seymour Publications, 1982.

This is another of the programs developed under the Lawrence Hall of Science at the University of California, Berkeley. Note also that most of the statistics are based on 1980 data. It would be good to include updated information from the 1990 census when it becomes available.

12. Teri Hoch Perl and Joan M. Manning Women, Numbers, and Dreams Santa Rosa, CA: The National Women's History Project, 1982.

13. Family Math is dedicated to helping Families learn about mathematics together. EQUALS is the program used to encourage girls to expand their mathematical skills mostly by making teachers more aware of the problems girls have and helping them find ways to work through the classroom environment. SPACES is aimed specifically in helping girls become more aware of the sciences as career options.

14. The address for the following is Lawrence Hall of Science, University of California, Berkeley, California, 94720, phone (415) 642-1823

Sherry Fraser, SPACES (Solving Problems of Access to Careers in Engineering and Science.
Jean Kerr Stenmark, Virginia Thompson and Ruth Cossey, Family Math, Berkeley, CA: Lawrence Hall of Science, 1986

EQUALS, and More EQUALS Berkeley, CA: Lawrence Hall Of Science, 1982, and 1990

Tim Erickson, Get It Together (Math Problems for Groups Grades 4-12).